

The effectiveness of visitation proxy variables in improving recreation use estimates for the USDA Forest Service

Donald B. K. English*, Susan M. Kocis, J. Ross Arnold, Stanley J. Zarnoch & Larry Warren

Southern Research Station, 320 Green St., Athens, GA, 30602, USA; e-mail: denglish@fs.fed.us

Abstract

In estimating recreation visitation at the National Forest level in the US, annual counts of a number of types of visitation proxy measures were used. The intent was to improve the overall precision of the visitation estimate by employing the proxy counts. The precision of visitation estimates at sites that had proxy information versus those that did not is examined. Results show that using visitation proxy information reduces sampling needs by about 25%. Characteristics of the types of visitation proxy information that performed best and worst are discussed.

Key words: Double sampling, variance, recreation, use estimates, efficiency.

Introduction

Managing a large system of land for multiple purposes, including recreation, requires accurate information about the levels of each of the set of outputs that come from those lands. For the United States Forest Service, the relevant unit of management is a national forest, most of which cover over one million acres. Most also include a large number of developed sites, roads, trails, and wilderness areas used by the public for recreation. A combination of highly decentralised reporting protocols and assigning low priorities to the relatively costly activity of systematically measuring visitation has led to a situation wherein the reported levels of recreation visitation are increasingly questioned regarding their accuracy and interpretation.

In response to the need for improving the credibility and consistency of its reported visitation estimates, the USDA Forest Service initiated in January, 2000 a nationwide, systematic program for measuring and monitoring the volume of recreation at the national forest level. This National Visitor Use Monitoring (NVUM) programme is intended to be part of the agency's ongoing

efforts to monitor its resources and outputs. This effort is somewhat of a departure from past agency efforts in measuring and reporting recreation visitation, in that the determination of the research method, definition of each forest's sampling frame, analysis of collected data, and reporting are guided or directly accomplished by a national team, rather than being done solely at a more decentralised forest level. A further departure was to report confidence interval limits as well as the estimate of visitation.

Given the expected size of the visitation quantity to be estimated, and the scope of agency lands to be sampled each year, and a limited budget for accomplishing the sampling, it was necessary to find as many ways as possible to reduce the variance associated with the visitation estimate. One method was to stratify the sample according to the expected used level of exiting recreation visitation. Another, and perhaps more important method, was to make use of visitation-related annual or seasonal counts that are routinely compiled by the agency at a number of its recreation sites. Incorporat-

*corresponding author

ing this sort of additional data to improve a recreation visitation estimate is the idea behind double sampling.

The double sampling method of estimating recreation visitation is an approach that has been used successfully for a number of years to estimate site-level recreation use (James & Ripley 1963; James 1967; James & Henley 1968; Watson et al. 2000). On a set of sample days, both recreation use and the level of some variable that can serve as a proxy for visitation are measured. Analysis, typically consisting of OLS regression, establishes the relationship between the visitation proxy variable, and actual visitation (James & Ripley 1963; Wagar 1969; Tarbet et al. 1982). Applying the relationship that has been estimated from the sampled days to the annual or seasonal total count of whatever variable is used to proxy visitation gives the total visitation estimate.

Double sampling can often yield relatively precise estimates of visitation (Tarbet et al. 1982). Its great advantage is that it makes use of an existing seasonal or annual count, which is known and not estimated, of a visitation-related variable. However, in some instances the results may not be useable either because of exceptionally wide confidence intervals (James & Henley 1968) or insignificant regression coefficients (Tarbet et al. 1982). The alternative is often to treat the sample days as a stratified sample that ignores the visitation proxy information, and develop estimates of total visitation following standard sampling procedures (Tarbet et al. 1982; Cochran 1977).

Variables that have been used to proxy for visitation include traffic counts, self-registration records, water use, parking lot use, and numbers of information brochures taken (Watson et al. 2000). Wagar (1969) noted that of these, the worst performer could be traffic counts, because of a "fairly loose relationship" between traffic counts and recreation use. Watson et al. (2000) noted that the accuracy of self-registration stations for wilderness can vary, and that certain types of users may be under-represented. Wagar (1969) stated that desirable characteristics for proxy variables are that they can be measured inexpensively and reliably, that they be closely related to actual visitation, and that the relationship with visitation be relatively stable across sites.

It is not clear how much precision is gained by using annual total counts of the visitation proxy variable, compared to what the estimate would be in its absence. Most of the empirical research in this area was undertaken more than 25 years ago. Since then, there have been improvements in traffic counters, as well as increases in the number of sites that charge user fees or require use permits. There does not exist a comparison of the relative efficiency of a set of variables readily available to today's land-managing agencies. This

paper examines the statistical efficiency of the types of visitation proxy information used in the USDA- Forest Service's efforts to measure recreation visitation. We compare the variability of visitation estimates at the forest level for the set of sites that had some sort of visitation proxy to the sites that did not.

Data and research method

From the beginning of January 2000 through the end of September 2001, 61 different National Forests were involved with sampling for the Forest Service's National Visitor Use Monitoring (NVUM) effort. Each sampled forest first identified every developed recreation site, including both overnight sites such as campgrounds and lodges, and day use sites such as picnic areas and ski areas, as well as wilderness trailheads and access points to the general forest area. These four types of sites formed one level of site stratification. For each site, every day in the year that the site was open was classified according to whether the expected exiting volume of recreation visitation was high, medium, or low. The spatial-temporal combination of a recreation site and a calendar day (a site-day) comprised the primary sampling unit for this study.

In addition, each site-day was classified as to whether some credible visitation proxy variable existed or not. To control the quality of the proxy variable, it was required that at least 80% of site visitors comply with the proxy count. Some visitation proxy measures covered every day of the year, including permanent traffic counters along roadways, at parking lot entrances, or at entrances to developed sites such as visitor centers. Some were operational for the entire portion of the year that the site was open, such as fee envelopes collected at some campgrounds, entrance fees to some developed day use sites, or mandatory permits allowing use of some wilderness areas. Still others were available for only part of the year that a site was in operation, including ticket sales at ski areas (where the area might be open for hiking during the summer), or concessionaire records for the period of the year they operated developed campgrounds.

Several different scales of visitation proxy information were also available. In some cases the visitation proxy measure counted vehicles (traffic counter on roads, or parking fees), some counted individuals (ski area ticket sales, or turnstiles at interpretive centers). Others counted site use, such as per-campsite fees, rooms at lodges, or remote cabin rentals, and still others counted the number of groups, such as wilderness permits, or reservations for large-group shelters. Table 1 describes the 19 types of visitation proxy information that were available on at least some of the forests, and what units of information were reported.

Table 1. Description of visitation proxy variables used.

Code	Definition of visitation proxy variable	What units were reported
FR1	Fee receipts or tickets, 1 per individual, such as at ski areas or visitor centers	# of tickets or fees sold
PTC1	Permanent Traffic Counters that count individuals	# of people counted (one-way)
RE1	Registration forms, 1 registration per person	# of registrations
SV1	Skier Visits, 1 per skier day of use	# of skier visits/skier days
TB1	Toll Booth, where 1 toll = 1 person	# of tolls collected
FR2	Fee receipts or tickets sold, 1 per group of 14 or fewer people	# of tickets or fees sold
MA2	Mandatory Wilderness permits issued, 1 per group	# of permits
RE2	Registration forms, 1 registration per group of 14 or fewer people	# of registrations
FE3	Fee envelopes issued per vehicle	# of fee envelopes collected
FR3	Fee receipts or tickets sold, 1 per vehicle	# of tickets or fees sold
PTC3	Permanent Traffic Counter that counts vehicles	# of vehicles counted (one-way)
TB3	Toll Booth, where 1 toll = 1 vehicle	# of tolls collected
DUR4	Daily use record of sites with PAOT of 14 or less, where records are of occupied sites per day	# of sites occupied per day
FE4	Fee envelopes issued per site with a PAOT of 14 or less	# of fee envelopes collected
RE4	Registration forms for room nights, 1 per room night	# of room nights sold/occupied
SUP4	Special Use permit issued per site, where one permit is issued per group of 14 or fewer people per visit not for entire season	# of permits issued
DUR5	Daily use record of sites with capacity of 15 or more, where records are of occupied sites per day	# of sites occupied per day
FR5	Envelopes, permits, or tickets sold, 1 per group of 15 or more	# of envelopes, permits or tickets

Of the types of proxy information listed, the ones used most often were for developed sites. Forty forests made use of site-level daily use reports (DUR4), and 31 used fee envelopes (FE4) for campgrounds or picnic areas where fees were assessed by campsite or picnic table. Skier visits were reported by 20 forests. Eighteen forests use per-person fee receipts, most often ticket sales at ski areas. Only 13 forests used some sort of permanent traffic counter, whether for vehicles or individuals.

Within each site type, all of the site days for which a particular visitation proxy measure was available defined a sampling stratum. For example, for all overnight use developed sites, the set of site days for which a fee envelope collection system was available to serve as a visitation proxy were placed in the same sampling stratum. For the set of site days for which no visitation proxy existed, sampling strata were defined by site type and expected exiting volume of visitation.

For site days without visitation proxy data, the number of daily exiting visits was estimated by placing a traffic counter at the site for 24 hours. Interviews occurred during a six-hour period, to determine the proportion of traffic that was completing a recreation visit, and the average number of persons per vehicle. Mean and variance of daily visitation were calculated across all days in a sampling stratum, and expanded to the forest population of site days in that stratum following

standard stratified random sampling procedures (Cochrane 1977).

Visitation for site days that had visitation proxy measures was estimated via double sampling. On sample days, surveys of individuals were conducted to obtain a daily estimate of a coefficient that calibrates the visitation proxy information. For example, for traffic counts the proportion of recreating vehicles and average people per recreating vehicle were calculated. In effect, these allow an estimate of visits per unit of the proxy variable count. Mean and variance of the calibration coefficient for a sampling stratum were calculated across all of the sample days in the proxy stratum. Since annual counts for visitation proxy information were known without error, the only source of variability is day to day variation in the calibration coefficient. For vehicular traffic counts, there is daily variation in both the proportion of traffic that are recreating vehicles, and in the number of people per vehicle. Multiplying the mean calibration coefficient by the annual total count of the proxy variable provided the estimate of visitation.

Of the 61 forests sampled, 57 had one or more types of visitation proxy information. For these forests, between ten and fifteen percent of the total population of site days had some sort of proxy visitation measure. Overall, sampling rates for strata with visitation proxy information was about the same as for sampling strata that lacked proxy information.

Evaluation of proxy data

We expected there would be less day-to-day variation in the calibration coefficient for proxy information than there would be in per-day visitation estimates for non-proxy strata. Thus, incorporating the visitation proxy data into the research design was expected to reduce the variance in the total visitation estimate for each forest. To evaluate whether this was true or not, we chose to compare coefficients of variation (CV) for non-proxy versus proxy strata for each forest. The CV was used as a measure of the precision of the visitation estimate and is defined as:

$$CV = 100 \cdot \frac{\sqrt{VAR}}{TOTAL}$$

The CV shows the variance of an estimate relative to the size of the estimate itself. For our purposes, we expect CV for visitation estimated for the set of site days for which there is visitation proxy data to be much lower than those for visitation estimates for the set of site days that did not have proxy data.

The results of this comparison show that making use of visitation proxy information greatly increases the precision of resulting visitation estimates. Across all 61 forests, the average of the CV ratios for the non-proxy portion of visitation was 19.83 (Table 2). None had CV ratios of less than 10.0, although about one-third had ratios between 10 and 15, and about the same number had a CV ratio between 15 and 20. Five had CV values over 35. Across the 57 forests that used visitation proxy data, the average of the CV ratio for that portion of their visitation was 10.76, or about half as

large as the comparable measure in the estimate of non-proxy strata. Thirty-three of the forests had CV ratios for the proxy visitation strata under 10.0. Twenty more had values between 10 and 20, and only two had CV ratios over 35.

There were some unexpected results in the CV comparisons that merited further examination. In particular, there were ten forests for which the CV for proxy visitation was larger than for the non-proxy. For each forest, we identified which types of visitation proxy information resulted in the least precise visitation estimates and sought the cause. Across the 10 forests, there were only four different types of proxy information that generated the anomalous results.

Permanent traffic counters on forest roads as proxy information for visitation to parts of the general undeveloped portion of the forest were the types of proxy information that yielded the least precise results. To calibrate the traffic counts, individual interviews obtained two pieces of information. First was the proportion of vehicles on that day that were finishing their recreation visit to the forest. Counting visitors as they begin or end their forest visit eliminated the possibility of double counting the same person. Second was the average number of people in each vehicle that was completing a recreation visit. The daily proportion of exiting traffic finishing a recreation visit ranged widely across sampled days, for some forests from less than 40 percent to 100 percent. In other cases, the proportion was more stable across days, but the daily average number of people per vehicle ranged from just about 1.2 to almost 6.8. Here, it was the combination of daily means of the proportion that were finishing a recreation visit and the average people per vehicle that generated higher variability.

Number of tickets sold at downhill ski areas also performed poorly as a visitation proxy. The annual proxy measure was the total number of tickets sold by the ski area. That total usually did not distinguish between single day tickets, multiple-day (weekend) tickets, and season passes. Calibration entailed converting number of tickets to number of visits. The problem was caused mostly by season passes. Across forests, between one-quarter and one-half of the people interviewed indicated their ticket represented only one site visit. These would be people who purchased single-day tickets. However, a number of those interviewed indicated that their ticket, most likely a season pass, represented between 50 and 100 site visits. The wide range of responses across individuals caused high variance in the resulting calibration coefficient and visitation estimate.

Two related types of visitation proxy measures that had mixed results counted either campsite nights occupied, or fee envelopes collected. These measures had high variability on forests that had campgrounds with both family-sized sites, and large-group (25 or more

Table 2. Comparison of coefficient of variation (CV) ratios, between strata that did and did not have visitation proxy data.

	Sampling strata	
	Without proxy data	With visitation proxy data
Mean CV Ratio	19.83	10.76
Number of forests with CV ratio:		
Under 10.0	0	33
10.1–15.0	20	11
15.1–20.0	19	9
20.1–25.0	12	1
25.1–35.0	5	1
Over 35.0	5	2
Mean site visits per forest	1,622,000	493,000
Mean sample days	162.6	20.3

people) sites. To convert from either campsite occupancy or fee envelopes to visits, the first step was to divide by average nights per visit or average envelopes used per visit. Typically, the average of these measures was fairly stable across sites and sample days. However, for both we needed to multiply by the average camping party size. On some sample days, only family-sized groups and individuals were interviewed, so the average party size was about 2.0. On other days, one or more large groups were encountered, so the average party size on those days was 10 or more. A potential solution for this is to separate large group and small group sites into different sampling strata.

Sample size reduction

Overall, it appeared that using the visitation proxy data was well worth the effort. However, the gains become more tangible if we could estimate how many sample days were saved. Our project allocated about \$ 375 per sample day to forests to accomplish the sampling. Quantifying sample days would allow us to approximate cost savings. To do that, we project means and variances from the sampling strata without visitation proxy data to the entire population of site days on each forest. We compute what sample size would have been needed to reach the CV level actually observed when using visitation proxy data and allocating sample days to calibrate that data.

The determination of the number of non-proxy site days required to achieve a desired CV for a forest surveyed under a stratified random sampling design used three types of information obtained from the original survey. First, the total number of site days (N_h) in each site type-use level stratum was obtained by treating every site day as if no proxy information was available. This step quantifies the site-day population if no proxy information existed. The strata weights (W_h) were defined simply as the proportion of total site days in stratum h , again under the assumption of no visitation proxy information. Next, daily visitation means (y_h) and variances (s^2_h) were approximated by assuming the estimated means and variances from the original data for the non-proxy sampling strata.

The above quantities were used to derive an estimate of the total number of site visits defined as:

$$TOTAL = \sum_{h=1}^L N_h \bar{y}_i$$

with estimated variance defined as

$$VAR = N^2 \sum_{h=1}^L \frac{W_h^2 s_h^2}{nh} - N^2 \sum_{h=1}^L \frac{W_h^2 s_h^2}{nh}$$

where

N = the sum of the N_h and

n_h = the number of site days sampled in stratum h .

Since TOTAL and VAR are fixed except for the n_h 's, a desired CV can be obtained by iteratively adjusting the n_h 's until the specified CV is achieved. Summing across strata yields the total sample size n associated with the target level of precision. For simplicity in computing same size savings, we simply increased the n_h 's in every sampling stratum by the same proportion.

The results for this analysis show that for 18 of the 61 forests, eliminating proxy visitation information and the associated sample days to calibrate proxy counts would allow a reduction in their overall sampling burden without sacrificing accuracy. These forests fell into one of three categories. Twelve of these forests were ones that used at least one of the types of proxy visitation information that have been shown to have relatively higher variability. For them, the reduced sample size reflects the relatively lower variability in the non-proxy sampling strata. The other six were forests where sampling strata that used visitation proxy information made up very small portions (sometimes less than 10%) of the forest's total visitation. In these instances, sampling gains existed because the sample days used to estimate the small amount of visitation in proxy sampling strata would have been better used improving the visitation estimate of the much larger non-proxy sampling strata.

However, on the remaining 43 forests, not employing the visitation proxy data would have required larger sample sizes to achieve the same level of precision. For these forests, using the proxy visitation data reduced the sampling need by an average of over 70 days per forest. Put another way, the sample sizes on these forests would have to be about 40% larger to reach the same level of accuracy.

Under the current sampling protocol, there were 11,087 sample days accomplished across the entire US in the two-year period. If none of the visitation proxy data were used, 13,817 sample days would have been needed to have the same level of accuracy in the estimate for each of the 61 forests. That additional 2,730 sample days translates to an increase of nearly 25%. Accomplishing these extra days would cost over a half-million dollars per year in staff time. Further additional costs would be incurred for printing and mailing survey forms, data entry, and data cleaning.

Discussion and conclusion

The analyses presented here show that using a relatively wide range of visitation proxy information did im-

prove the precision of the estimated visitation to National Forests in the US, and reduce the overall sampling level that was needed to obtain accurate visitation estimates. Not surprisingly, the best results were obtained at day-use developed sites where the proxy count was nearly identical with the target measure of visitation. For example, ski areas that reported skier visits had essentially zero variance, since the counts needed no conversion to visits. This particular proxy measure was especially important in reducing overall variance, because of the high volume of visits that occur on those sites. Other types of sites that charge fees or get counts on a per-person or per-visit basis had equally low variances. However, individual traffic counts, such as turnstiles at visitor centers, were not as accurate, because the counts had to be adjusted for return entrants on the same visit, or people who entered for non-recreation reasons, such as to just use the bathrooms.

Proxy counts for use of overnight developed sites with homogenous user patterns yielded accurate visitation estimates. Regardless whether the proxy count was number of campsite-nights occupied, or number of fees collected either per site or per vehicle, if the campground was composed of just family-sized sites, and the typical length of stay was a week or less, the resulting visitation estimate was more accurate than for similar overnight sites that did not have proxy information. On the other hand, if some sites within the same campground were designed for large groups and some for small groups, then the visitation proxy did not always result in accurate visitation estimates.

A few wilderness areas required that all groups using the area obtain a permit. These groups are typically limited to not more than eight persons. Resulting visitation estimates were far more accurate than in wilderness areas that did not require permits.

Permanent vehicular traffic counters, especially those placed on roads that provide access to the general forest performed worst. Forest roads are used by commuters, loggers, agency staff, and others on non-recreation trips. The percentage of vehicles on non-recreation purposes can vary widely by season and day of the week. Variability was very high for ski areas that reported ticket sales, rather than skier visits. In general, vehicle-based counts resulted in less precise visitation estimates than counts based on number of sites used or number of people entering.

The coefficients calibrating any of the proxy counts were applied to all sites that obtained that type of count. As a result, the gains in sampling were relatively greater on forests that had a large number of sites of any particular type. With overnight sites, for example, the best visitation estimates were obtained where there

were a large number of campgrounds with the same proxy measure, where the campsites were often in use, or where the campgrounds were large in term of the number of campsites in them. Typically, those forests that used many different visitation proxy measures each for a few locations did not have as accurate a visitation estimate as ones that used a smaller array of proxy measures for a larger number of sites.

There were other reasons to use the visitation proxy data as well. Personnel costs for sample days were reduced. Setting up the 24-hour traffic counter required at least two trips to the interview site. Travel from staff offices to interview sites often took several hours. Because 24-hour traffic counts were not needed for proxy sites, forest staff made at least one less trip per interview day. Some of this savings was offset by the staff time needed to collate and verify the annual counts from the various proxy sites.

Perhaps a more important benefit of using the visitation proxy data is that it provides a means by which national forests can inexpensively estimate visitation in non-sample years. First, the forest must obtain the appropriate counts for proxy sites in the years between sampling. If the calibration coefficient for the proxy count is stable between survey cycles, those coefficients can be used with the proxy counts to approximate visitation in the off years. Summing over all proxy information types gives a new estimate of proxy site visitation. Further, if the forest-wide ratio of proxy site visits to total visits is assumed constant, then applying the ratio of total visits to proxy site visits from the sample year to the off-year estimate of proxy visitation, results in an estimate of total visitation in the off-year.

Clearly, using this type of information has the potential to dramatically affect the sample size needed to accurately estimate visitation for a large system of recreation sites or areas. However, before using visitor proxy information in that fashion, researchers and managers need to consider certain issues carefully:

- (1) How close is the proxy count to the measure of visitation desired? What other pieces of information are needed to convert the proxy counts into actual visit estimates? How accurate or variable is that information? How will that information be elicited?
- (2) Does the visitation proxy account for all use of the site? If not, how can an accurate measure of its proportion be obtained?
- (3) The research process presumes that the proxy count is an actual count, and known without error. Can the visitation proxy actually and accurately be obtained from field staff? Can the count be verified readily?

- (4) Are there other uses of the proxy counts, such as approximating visitation in subsequent years, that enhance the value of using those counts?
- (5) How large is the set of sites or site-days whose visitation can be estimated via proxy measure? Will many or few different measures be needed? Can several measures be combined into some common proxy metric? Proxy measures that can be used for greater amounts of visitation will be the most valuable.

Double sampling was initially designed to be used to accurately estimate recreation visitation at the site level. However, this research has examined its value in improving visitation estimates for larger systems of recreation resources. Within the types of proxy information typically and reliably collected by the US Forest Service, we have identified characteristics of several of the types that perform best and worst, and quantified the role these can play in reducing the overall costs of estimating visitation. Most of the proxy measures examined here are linked to either mechanical counts, such as traffic counters, or administrative counts of fees collected, site occupancy, or permits dispensed. Additional research is needed to examine the relative efficiency of other types of counts, including photographic measures of visitation. We hope that these results can assist planners and researchers in their efforts to develop accurate measures of visitation on the recreation resources of interest to them.

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